Upper Permian and Triassic of the Precaspian Depression: stratigraphy and palaeogeography

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ABSTRACT
The stratigraphic serie of the Precaspian Depression during the Upper Permian and the Triassic is analysed. Data from seismic sections and from numerous boreholes are used. The lithological composition and the palaeontological content are cleared for all the time interval. Three palaeogeographical maps are drawing for the Kazanian, the Lowet Triassic and the Middle Triassic. The evolution of palaeoenvironments is restored in relation to the tectonic events and the fluctuations of the Boreal Sea and the Palaeo-Tethys Ocean.

KEY WORDS
Precaspian Depression,
Upper Permian,
Triassic,
stratigraphy,
palaeogeography.

RÉSUMÉ
Le Permian supérieur et le Trias de la Dépression Précaspienne : stratigraphie et paléogéographie.
La série stratigraphique de la Dépression Précaspienne est analysée pour le Permien supérieur et le Trias. Les données de profils sismiques et de nombreux forages sont utilisées. La composition lithologique et le contenu paléontologique sont précisés pour l'intervalle de temps considéré. Trois cartes paléogéographiques sont établies pour le Kazanien, le Trias inférieur et le Trias moyen. L'évolution des paléoenvironnements est établie en relation avec les événements tectoniques et les fluctuations de la mer Boréale et de l'océan Paléo-Téthysien.

MOTS CLÉS
Dépression Précaspienne,
Permien supérieur,
Trias,
stratigraphie,
paléogéographie.

INTRODUCTION

The Upper Permian and the Triassic of the Precaspian Depression and adjacent areas are represented by marine and continental deposits. The complex original relationships between these deposits have been modified by the salt tectonogenesis. The salt domes are widely distributed (Fig. 1) and the upper part is often eroded. The most complete sections are in the depressions between the domes. We present here new data which complete the previous work (Kukhtinov 1976, 1984) on stratigraphy and depositional conditions.

STRATIGRAPHY (Table 1)

The Upper Permian (P_2)

The Upper Permian deposits are irregularly studied. They were drilled during the oil and gas prospecting, mainly on the borders of the Depression (Figs 2-5). In the central part of the basin, in the Aralsor 1 borehole (locality 2 on Figs 6, 7), the Upper Permian succession is recognized between 6806 and 5492 m. The base of the Upper Permian is not reached. The most complete sequence is located on the eastern border of the Depression where all substages are characterised by their palaeontological content (example Lugov borehole, No. 45 on Figs 6, 7).

The Ufimian (P_2u)

In the eastern part of the Depression, two terrigenous units were recognised (Fig. 6). The lower one (P_2u_1) is grey (200-300 m) and has not clear boundary with the underlying Kungurian. It is composed of fine-grained sandstones, claystones and aleurolites – aleurolites is more or less equivalent to siltstone in Russian literature. The upper unit (P_2u_2) is red (200-300 m) and is mainly represented by sandstones. In both units, anhydrites and salt lenses are sometimes interlayered and typical ostracods of the *Darwinula angusta* zone from the Russian platform Ufimian (see for example Molotovskaya 1997) are recovered (*Darwinula lubimovae* Kashevarova, *D. angusta* Mandelstam, *D. lanzetiformis* Kashevarova, *D. fainae* Belousova, *D. burajevoensis* Palant, *D.* cf. *trita* Palant, *D.* cf. *pyriformis* Kashevarova). The bivalve *Palaeomutela* cf. *stegocephalum* Nechaev, as well as miospores and conchostraceans, permit the correlations with the synchronous deposits of Aktjubian Pre-Uralian zone.

In the central part of the Depression, the red argilites and sandstones with inclusions of anhydrite drilled in the Aralsor well (6630-6806 m) are related to the Ufimian (Fig. 6). The thickest Ufimian deposits (more than 581 m) were drilled in Linjovka 8 well (locality 43 on Fig. 7) on the northern edge. They are composed of grey and red terrigenous, carbonated and sulfate-halogenous rocks with non marine ostracods (*Darwinula abunda* Mandelstam, *D. acervalis* Mandelstam, *D.* aff. *parphenovae* Belousova, *D. subaclinis* Zhernakova), bivalves (*Palaeomutela* ex gr. *ovataeformis* Gussev, *P.* cf. *pseudoumbonata* Gussev, *Anthraconaia rhomboides* Netschajev), conchostraceans, fishes and charophytes.

In northern and western edges of the Depression, the Ufimian is defined between the Kungurian anhydrites and the Kazanian clays and carbonates; 30 to 70 m of red and grey sulphate-terrigenous, halogenic and rarely carbonates rocks are recognised. In the south-western part, the Ufimian terrigenous deposits (63 to 1242 m) are distinguished by spores and pollens. The spore and pollen spectra shows predominance of *striatiti* (up to 52%) and Vittatina (27 to 37%). These deposits are included in the Volozhkovskaya suite (without subdivision) from Ufimian-Kazanian (Pronicheva & Savinova 1982).

The Kazanian Stage (P_2kz)

It is represented by two substages (lower and upper) in most of the Precaspian Depression and its northern and western adjacent areas.

Lower Kazanian substage (P_2kz_1). The Kalinovskaya suite is composed of clays, dolomites, limestones, rarely sandstones with marine macro- and microfauna: brachiopods [*Cancrinella cancrini* Verneuil, *Beecheria netschaevi* Grigorieva, *Cleiothyridina reussiana* (Keiserling), *C. pectinifera* (Sowerby)], bivalves *Pseudomonotis*

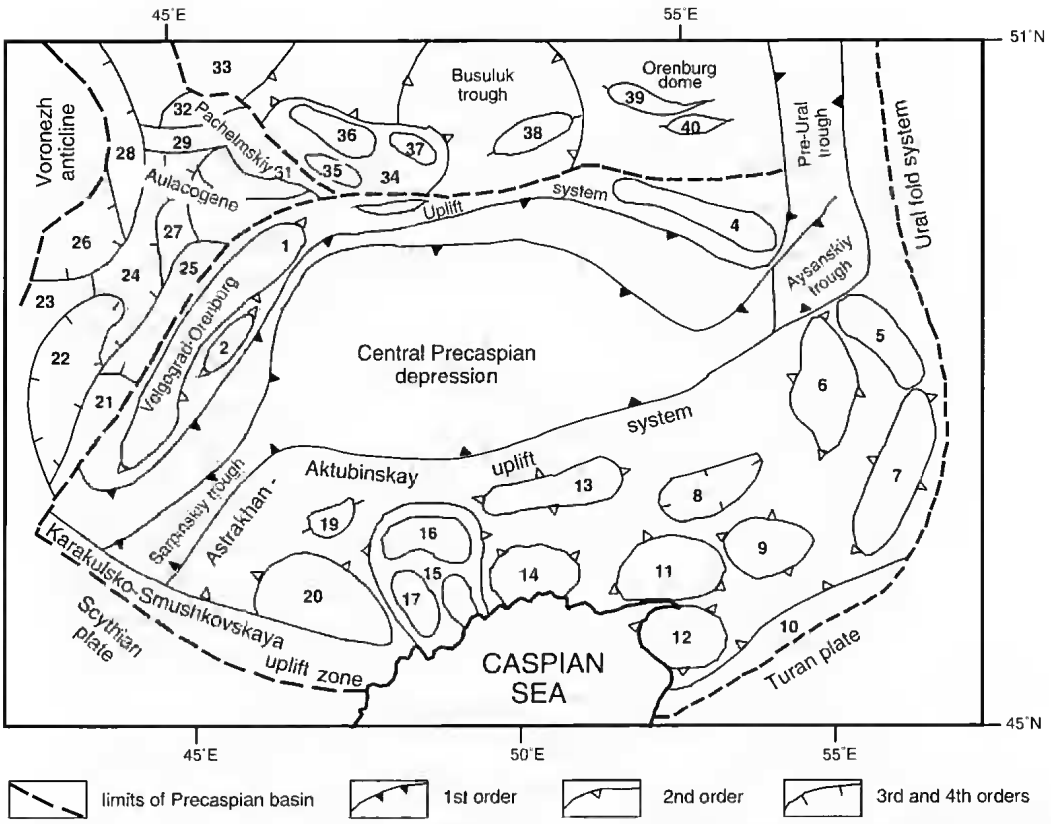

FIG. 1. — Tectonic chart of the Precaspian Depression. Tectonic features: **1**, Akhtubinsk-Palassowski megamound; **2**, Dzhanybeckoe rise; **3**, Attatinsk-Nikolskiy mound; **4**, Karachaganak-Koblandinskay uplift; **5**, Temirskiy dome; **6**, Kzyldsharskiy dome; **7**, Zharkamyssiy dome; **8**, Dossorskiy trough; **9**, Biikzhalskiy dome; **10**, South Emba uplift; **11**, Guriev dome; **12**, Karaton-Tengiz uplift; **13**, Zhaykskiy dome; **14**, North-Caspian dome; **15**, Akkolskiy dome; **16**, Myntobinskay uplift; **17**, Kobyakovskoe uplift; **18**, Octyabrskoe uplift; **19**, Azgirskoe uplift; **20**, Astrakan dome; **21**, Suvodskaya uplift; **22**, Oikhovskay depression; **23**, Archedino-Don mound; **24**, Zhirnovsko-Umetovskiy mound; **25**, Antipovsko-Sherbakovskiy mound; **26**, Tersinskaya depression; **27**, Zolotovsko-Kamenskaya uplift; **28**, Karamyshskaya uplift; **29**, Elshano-Sergievskiy mound; **30**, Stephovskiy mound; **31**, Voskeresenskaya depression; **32**, Saratov displacements; **33**, Kazanlinskiy monud; **34**, Pugachevskiy dome; **35**, Marievskaya uplift; **36**, Balakovskaya uplift; **37**, Klintsovskay uplift; **38**, Kamelik-Chaganskiy mound; **39**, Zemlyanskiy mound; **40**, Syrtovskiy mound.

elengatula Netschajev, *Parallelodon kingi* Verneuil, *P.* cf. *striatus* (Schlotheim), *Edmondia elongata* House, *Bakevellia (Bakevellia) ceratophaga* (Schlotheim)], bryozoa [*Dyscritella incrustata* Morozova], foraminiferas [*Palaeonubeculariа uniserialis* Reitlinger, *P. fluxa* Reitlinger, *Geinitzina pusilla* Grozdilova, *G. spandeli* Tscherdynzev, *G.* cf. *postcarbonica* Spandel, *Nodosarina elabugae* Tscherdynzev, *N. netschevi* Tscherdynzev, *Spandellina* ex gr. *cordiformis* Gerce], ostracods [*Healdia subtriangula* Kotschetkova, *H. simplex* Roundy, *Healdianella vulgata* Kotschetkova, *H. parallela* Knight, *H.* ex gr. *osagensis* Kellett, *H.* ex gr. *panda* Kotschetkova, *Cavellina*? cf. *unica* Kotschetkova, *C.* ex gr. *edmistonae* (Harris & Lalicker)]. The thickness varies from 0 to 168 m.

In the south-western part of the Depression, the upper Volozhkovskaya suite is composed of red and grey terrigenous rocks. In the south, the Zhambay 22 well (noted 3 on Fig. 7) shows under the Triassic, terrigenous rocks with brachiopods, pelecypods, ostracods (*Darwinula* sp., *Moorea* cf. *facilis* Schneider) of lower Kazanian substage. In the east of the Precaspian Depression, the series (700 m), composed of regularly interlaid sandstones, aleurolites, argilites and limestones with locally salt lenses, is synchronous

	STAGE	HORIZON		SERIE	SUITE		
					West	Centre and North-West	East
T3	Rhaetian	Kusankudukian	T_{3ks}	Aralsorskaya			Kusankuduskaya
	Norian Carnian					Koktinskaya	Shalkarskaya-T_{3sk} / Koktinskaya-T_{3kk}
T2	Ladinian	Chobdian	T_{2ch}		Barmantsakskaya		Chobdinskaya-T_{2ch}
		Akmamykian	T_{2ak}		Sarpinskaya	Akmamykskaya	Akmamykskaya-T_{2ak}
		Masteksajskian	T_{2ms}			Masteksajskaya	Masteksajskaya-T_{2ms}
	Anisian	Inderian	T_{2in}	Akmajskaya T_{2ak}	Inderiskaya	Inderskaya	Kiiskaya / Tassholskaya T_{2in}
		Eltonian	T_{2el}		Eltonskaya	Eltonskaya	
T1	Olenekian	Baskuntchakian	T_{1bs}	Baskuntchakskaya	Enotaevskaya / Bogdinskaya / Aktubinskaya / Buzulukskaya	Zhulidovskaya	Akzharsajskaya T_{1kz}
	Induan	Ershovian	T_{1er}	Prikaspijskaya	Bugrinskaya	Ershovskaya	Kokzhidinskaya-T_{1kz} / Sorkolskaya-T_{1sk} / Blaktykolskaya-T_{1bl}
P2	Tatarian P_2t_2	Viatkian	P_{2vt}		Batyrmolinskaya	Viatkian	
		Severodvinian	P_{2sd}			Severodvinian	Severodvinian
		Urzhmian	P_{2ur}			Urzhumian	Urzhumian
	Kazanian P_2u_2	upper Kazanian	P_{2kz2}		Volozhkovskaya	upper Kazanian	upper Kazanian
		lower Kazanian	P_{2kz1}			Kalinovskaya	Kalinovskaya
	Ufimian P_2u	upper Ufimian	P_{2u2}			Sheshmian	Sheshmian-P_{2sh}
		lower Ufimian	P_{2u1}			Solikamian	Solikamian-P_{2sl}

TABLE 1. — Upper Permian and Triassic stratigraphic subdivisions of the Precaspian Depression.

with the Kalinovskaya suite. The organic remains are crinoids, ostracods (*Sinusuella* cf. *ignota* Spizharskyi, *Darwinula varsanofievae* Belousova, *D. irinae* Belousova, *D. isetica* Starojilova, *D. accomodata* Starojilova, *D.* ex gr. *tichwinskaje* Belousova, *Suchonella onega* Belousova, *S. belebeica* Belousova, *S. sacmarensis* Starojilova, *Darwinuloides edmistonae* Belousova, *D. sentjakensis* Sharapova, *D. triangula* Belousova), non marine pelecypods, miospores. They allow the comparison with the Akjubian (lower Kazanian or Kazanian) of Pre-Ural and Russian platform.

Upper Kazanian substage (P_2kz_2). The upper Kazanian substage is everywhere represented by terrigenous rocks. To the east of the Depression, the series is composed of sandstones with conglomerate at the bottom and argilite interbedded (mainly in the upper part). In this series (400-500 m), they are quite often non-marine bivalves [*Palaeomutela* ex gr. *krotovi* Nechaev, *P.* ex gr. *doratioformis* Gussev, *P.* cf. *umbonata* (Fischer), *P.* cf. *vjatkensis* Gussev, *Palaeanodonta rhomboidea* (Nechaev)], ostracods [*Darwinula varsanofievae* Belousova, *D. vinocurovi* Belousova, *D. accomodata* Starojilova, *D. inornatina* Belousova, *D. alexandrinae* Belousova, *Suchonella belebeica* Belousova, *S. onega* Belousova, *S. serpula* Belousova, *Darwinuloides sentjakensis* Sharapova, *D. edmistonae* Belousova, *D. triangula* Belousova, *Sinusuella ignota* Spizharskyi], spores and pollen which are characteristic of the whole Kazanian stage or of its upper substage in the most areas of the Russian platform.

In the central part of the Depression, the upper Kazanian substage is composed of red aleurolites and argilites with marine and non-marine ostracods [*Healdia* sp., *Healdianella vulgata* Kotschetkova, *Healdianella* sp., *Monoceratina* aff. *exilis* (Schneider), *Schneideria* ex gr. *kotschetkovae* Starojilova, *Darwinula* sp., *Suchonella sacmarensis* Starojilova, *S. tichwinskaja* (Belousova), *Placidea* sp., *Tomiella* sp.]. The thickness reaches 345 m.

On the northern Depression border, on the Kalinovskaya suite, the red argilites with anhydrite and salt inclusions, could be palaeontologically correlated with the upper Kazanian deposits

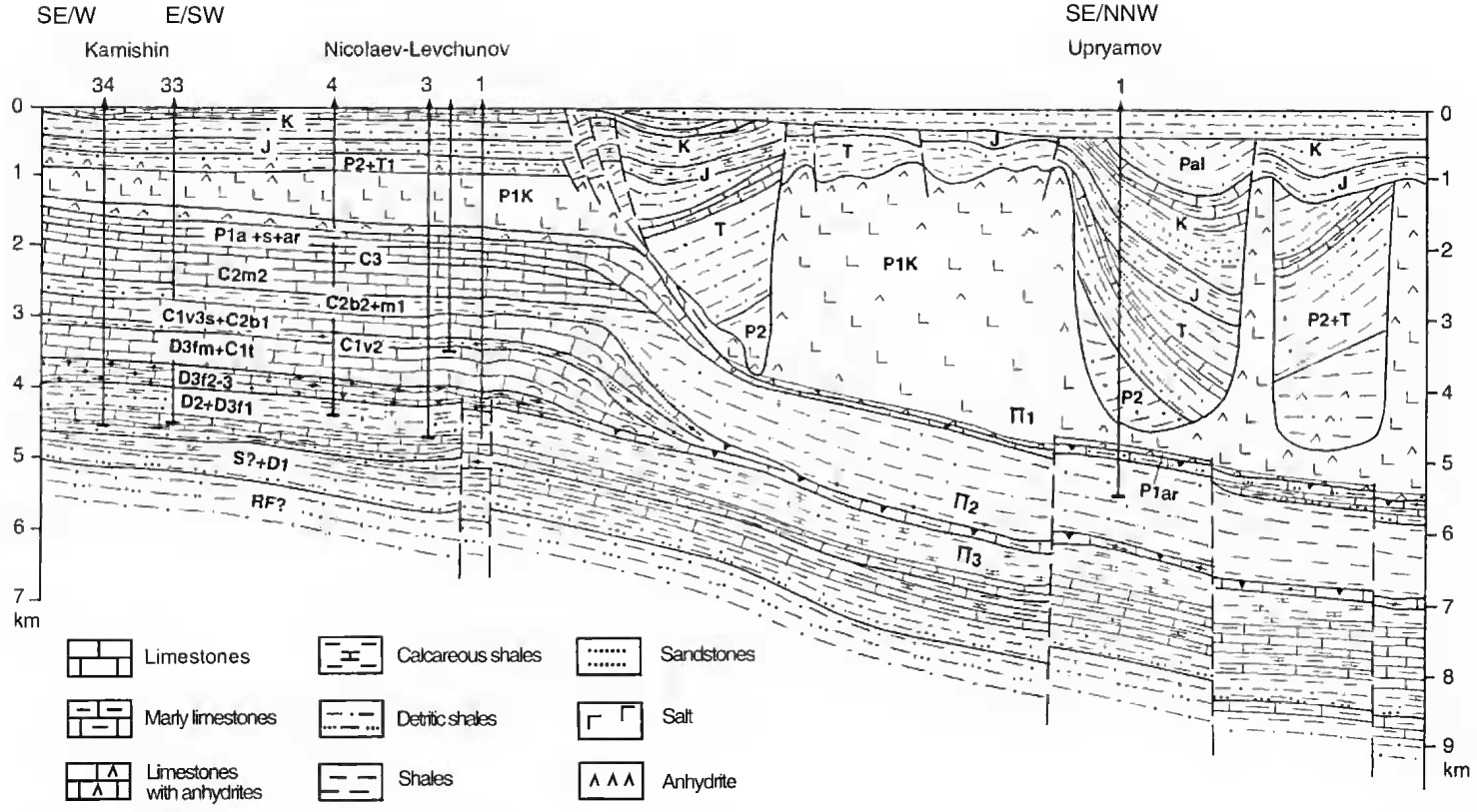

FIG. 2. — Geological-geophysical cross section SP 052 (location on Fig. 7). Western margin-Central part of Precaspian Depression. **PR3/Vd**, Upper Precambrian-Vendian; **FR**, Riphean; **S**, Silurian; **D**, Devonian; **D1**, Early Devonian; **D2**, Middle Devonian; **D3**, Late Devonian; **D3fr**, Frasnian; **D3f1**, early Frasnian; **D3f2**, middle Frasnian; **D3f3**, late Frasnian; **D3fm**, Famennian; **C1**, Early Carboniferous; **C2**, Middle Carboniferous; **C3**, Late Carboniferous; **C1t**, Tournaisian; **C1v**, Visean; **C1v2**, late Visean; **C1v3**, late Visean; **C2b1**, early Bashkirian; **C2b2**, late Bashkirian; **C2m1**, early Moscovian; **C2m2**, late Moscovian; **P1**, Early Permian; **P2**, Late Permian; **P1a**, Asselian; **P1s**, Sakmarian; **P1ar**, Artinskian; **P1k**, Kungurian; **P2kz**, Kazanian; **T**, Triassic; **T1**, Early Triassic; **J**, Jurassic; **K**, Cretaceous; **K1**, Early Cretaceous; **K2**, Late Cretaceous; **Pal**, Palaeogene; **N2**, late Neogene; **Π1**, **Π2**, **Π3**, the three main discontinuities; **F**, major fault.

of the Orenburg Pre-Ural adjacent area.
In other areas, there are no data reliable to the upper Kazanian substage.

The Tatarian Stage (P_2t)
Lower Tatarian substage (P_2t_1). In the eastern part of the Depression, the lower Tatarian is represented by red clays (600-800 m). The ostracods are non-marine (*Darwinula elongata* Lunjak, *D. teodorovichi* Belousova, *D. tichonovichi* Belousova, *D. fragiliformis* Kashevarova, *D. elegantella* Belousova, *D. perlonga* Sharapova, *D. torensis* Kotschetkova, *Suchonella nasalis* Sharapova, *Darwinuloides dobrinkaensis* Kashevarova). Some non marine pelecypods were found (*Palaeanodonta navalis* Nechaev, *P. verneuili* (Amaltisky), *P.* cf. *longissima* Nechaev, *P. fischeri* Amaltisky, *Palaeomutela ujatkensis* Gussev, *P. plana* Amaltisky, *Authraemaia* sp., *Microdontella* sp.). Spores and pollens confirm the stratigraphic attribution.
In the central part, the Arasol well (locality 2, Figs 6, 7) presents, in the interval 6045-5875 m, red-brown aleurolites and argilites with the non-marine ostracods (*Darwinuloides djurtjulensis* Palant, *Volganella* sp.) attributed to the lower Tatarian.
In the north-western part of the Depression, the series is formed of red clays, aleurolites, sandstones with anhydrite inclusions. It contains charophytes from the Tatarian and ostracods from the lower Tatarian (*Darwinula fragiliformis* Kashevarova, *D. elongata* Lunjak, *Suchonella nasalis* Sharapova) and from the upper Tatarian (*Suchonellina inornata* Spizharskyi, *S. parallela* Spizharskyi, *Suchonella stelmachovi* Spizharskyi). The thickness varies from 0 to 2030 m. Outside of the Depression, similar deposits were observed, with both substage ostracod assemblages, and have a thickness of 0 to 300 m.
In the south-western part, the red terrigenous deposits (about 1200 m) are related to the Tatarian Batyrmolinskaya suite by the presence of spores and pollens (complex j) as well as the ostracod *Suchonellina*.
Upper Tatarian substage (P_2t_2). It is clearly defined on the inner border of the eastern part of the Depression, where it is represented by sandstones and clays (up to 600 m) with ostracods (*Suchonellina inornata* Spizharskyi, *S. parallela* Spizharskyi, *Suchonella stelmachovi* Spizharskyi, *Volganella magna* Spizharskyi) characteristic of the North Dvinian horizon and which allow the correlations with Southern Urals (Molostovskaya 1997).
In the central part, in the Aralsor well (5875-5492 m) (locality 2 on Figs 6, 7), the upper Tatarian presents red and grey sandstones, aleurolites, argillites and clay marls with ostracods of the Viatkian horizon (*Darwinuloides tataricus* Posner, *D. svijazhicus* Sharapova).

As a whole, the Upper Permian has not been studied in full. It is mainly represented by red terrigenous deposits which are traditionally regarded as continental. In general in Russia, the lower Kazanian is marine. On the Depression periphery, there are red interbeds with marine fauna. The maximum thickness of the Upper Permian is located on eastern and southern borders of the Depression.

LOWER TRIASSIC (T_1)
The Lower Triassic deposits of the Precaspian Depression and its adjacent areas overlay with unconformity various Permian levels. In the central part of the Depression, the contact between Permian and Triassic is not known.
The Lower Triassic corresponds here to the international subdivisions (Induan and Olenekian). At the regional scale (Anonymous 1982), it is referred to the Ershovian and Baskunchakian horizons (Table 1).

The Ershovian (T_{1er})
It is accurately defined. It consists of continental red terrigenous deposits (aleurolites, argilites and rare sandstones; Figs 8, 9) with ostracods [*Darwinulla ovalis* Glebovskaya, *D. quadrata* Mischina, *D. dubia* Starojilova, *D. regia* Mischina, *D. gravis* Mischina, *D. pseudoinornata* Belousova, *D. postparallela* Mischina, *Gerdalia wetlugensis* Belousova, *Suchonella posttypica* Starojilova, *S. circula* Starojilova, *S. rykovi* Starojilova (*Darwinula quadrata-D. dubia* zone)], conchostracans [*Vertexia tauriconis* Lutkevich, *Cyclotunguzites gutta* Lurkevich], charophytes [*Vladimiriella globosa* (Saidakovsky), *V. wetlugen-*

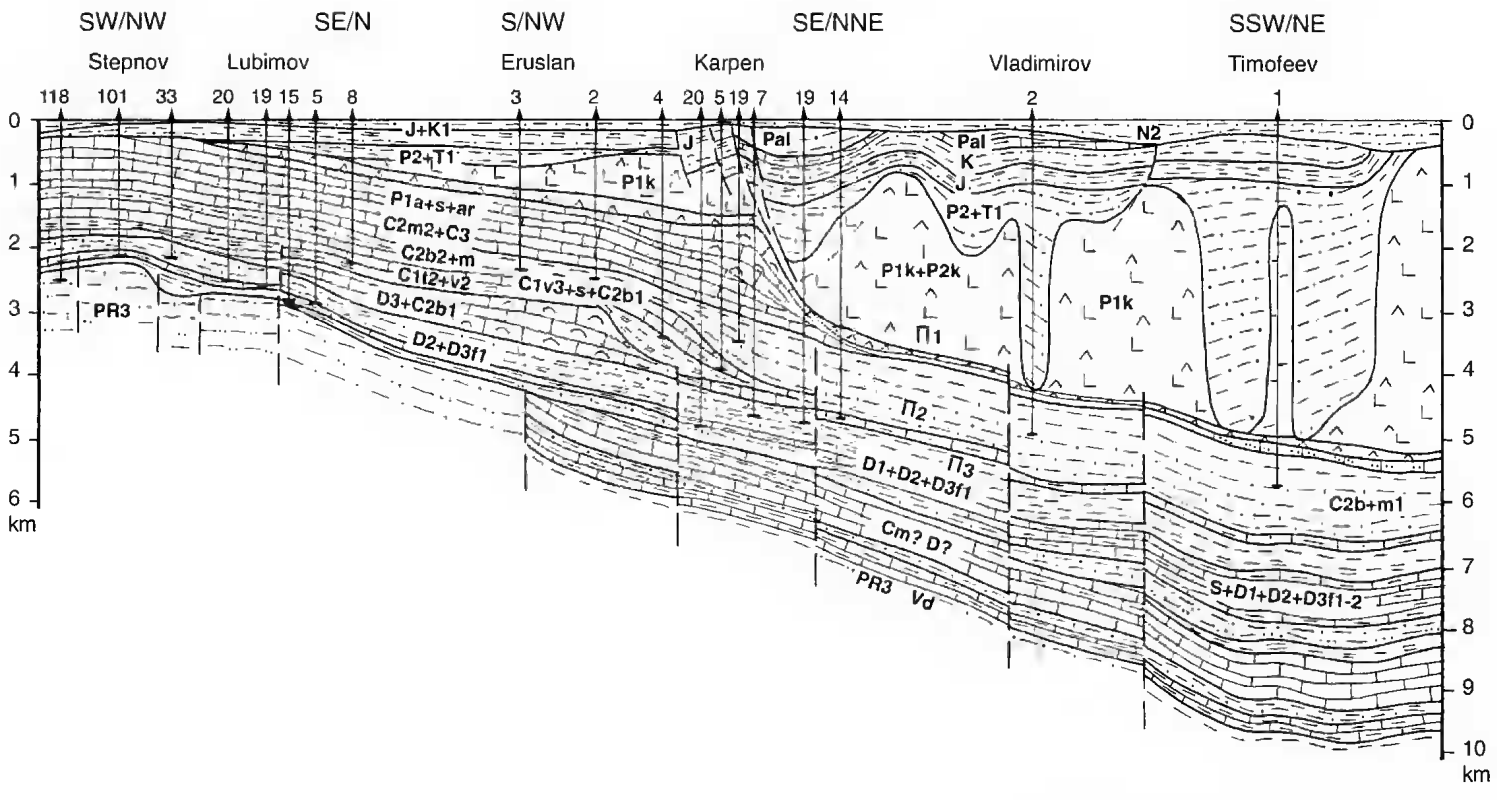

FIG. 3. — Geological-geophysical cross section GG 07 (location on Fig. 7). North-western margin-central part of Precaspian Depression. Legend: see Fig. 2.

sis Saidakovsky], spores and pollen.
Vertexia tauricornis are also known in deposits of middle part of the Vetluzhkaya series of the Moscow syncline, the Kopanskaya suite of the Volgo-Ural anticline, in the middle part of the Korenevskaya suite of the Prypiat trough of the Russian platform and in lower variegated sandstone in Germany (Nordhausen and Bernburg suites).

In the eastern part of the Depression (Blacktykol well; locality 46 on Figs 8, 10), the Blacktykolskaya, Sorkolskaya and Kokzhidinskaya suites are clearly identified. The Blacktykolskaya suite (maximum of thickness 90 m) overlies with unconformity the Permian. It begins by a conglomerate level following by sandstones and clays. To the east, this suite is absent and the Sorkolskaya suite lies on the Permian (Kenkiyak well; locality 44 on Figs 8, 10) with a maximum thickness of 87 m. The Kokzhidinskaya suite (T_{1kz}, Table 1; up to 140 m) is composed of clay sandstones with clay interbeds.
In others areas, the Ershovian horizon is undifferentiated, with red sandy clay deposits. The thickness varies from 0 to 340 m.

The Baskunchakian (T_{1bs})
This horizon combines the marine deposits of the Baskunchakian suite (Table 1) and its continental analogue. In Bolshoi Bogdo Mountain (the only outcrop in the area) four suites (West in Table 1) are distinguished.
The Busulukskaya suite. 96 m of red and grey sandstones without organic remains.
The Akhtubinskaya suite. 64 m of red aleurolite clays with numerous fossils.
Charophytes: *Porochara triassica* (Saidakovsky).
Ostracods: *Clinocypris triassica* (Schneider), *C. elongata* (Schneider), *Darwinula oblonga* Schneider, *Gerdalia longa* Belousova.
Conchostraceans: *Cyclotunguzites gutta* (Lutkevich), *Lioestheria blomi* Novojilov.
Ichtyofauna: *Gnathorhiza triassica baskuntschakensis* Minich, *G. bogdoensis* Minich, *G. otscheri* Minich, *Ceratodus multicristatus feodorensis* Minich (see also Minikh & Minikh 1997).
Bivalves: *Bakewellia lipatovae* Kiparisova.
The Bogdoninskaya suite. 24 to 100 m of variegated clays following by grey clays with limestones interbedded.
Cephalopods: *Tirolites cassianus* (Quenstedt), *Dorikranites bogdoanus* (Buch.), *D. acutus* (Mojsisovich).
Pelecypods: *Mytilus tuarkyrensis* Kiparisova, *Myalina dalailamae* (Verneuil), *Unionites fassaensis* (Wissmann), *U. canalensis* (Catullo).
Brachiopods: *Lingula*.
Tetrapods: *Parotosuchus bogdoanus* S. Woodward.
Fishes: *Ceratodus multicristatus multicristatus* Minich, *Gnathoriza triassica baskuntchakensis* Minich, *G. bogdensis* Minich.
Ostracods: *Triassinella chramovi* Schneider, *Clinocypris cognata* Starojilova, *C. conferta* Starojilova, *C. oleneca* Kukhtinov, *Darwinula rotundata* Luber, *D. parva* Schneider, *D. nota* Schneider, *D. acuta* Mischina, *Gerdalia dactyla* Belousova, *Bogdoella delicata* (Starojilova), *B. antiqua* Starojilova.
Charophytes: various *Porochara* and for the first time *Auerbachichara*.
Conodonts, conchostracans, plants, spores and pollen.
The Enotajevskaya suite. 57 m of grey and variegated sand-clays with charophytes (*Porochara* and *Vladimirella*) and ostracods dominated by *Gerdalia* (*Gerdalia dactyla* zone).

Laterally the Akhtubinskaya and Bogdinskaya suites (Table 1) are generally combined in a clay unit of 400 m thick. On the eastern border, the Akzarsajskaya suite overlays it in conformity and is represented by red sand clays up to 150 m. On the outer edges, to the north, the Krasnokutskaya suite consisted of sandstones following by clays (273 m) and to the west the Berezovskaya and Lipovskaya (or only Lipovskaya) suites (0-256 m) are transgressive and overlay the Permian or Upper Carboniferous. All these suites are referred to the Baskunchakian horizon.
The correlations could be well-established between Baskunchakian horizon and synchronous deposits of the Russian Platform by fishes (Minikh & Minikh 1997). The fauna of *Parotosuchus* is found also in the sections of Volgo-Uralian anticline, Preuralian and Pripyat troughs, Moscow and Mezensk synclines and in

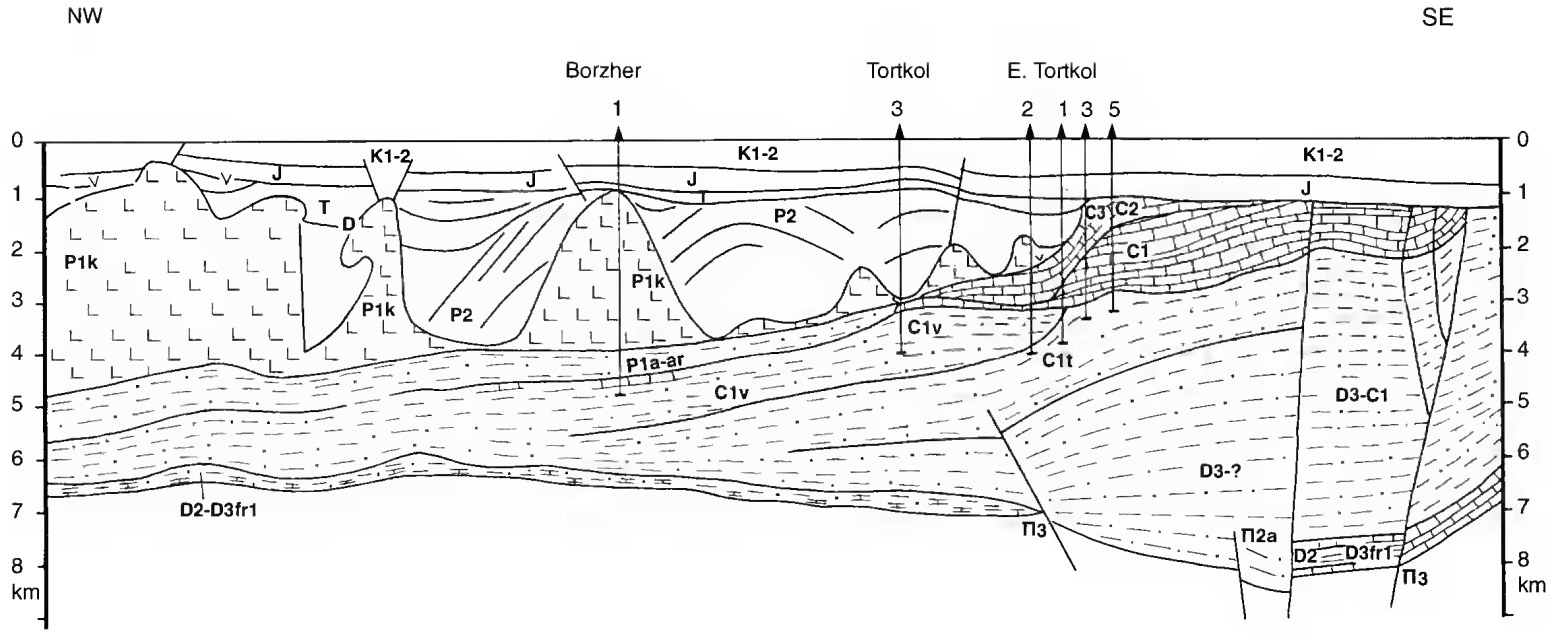

FIG. 4. — Geological-geophysical cross section GG 051 (location on Fig. 7). South-eastern part of Precaspian Depression. Legend: see Fig. 2.

the variegated sandstone of German basin. The ammonites *Dorikranites* and *Tirolites* allow to correlate with the upper Olenekian of Russia and with the Campile beds of Alpine Triassic and the Spathian Tirolites zone (Shevyrev 1990).

MIDDLE TRIASSIC (T_2)

The Akmajskaya and the lower Aralsordkaya series are attributed to the Middle Triassic (Table I).

The Akmajskaya series

It is distributed in most part of the Precaspian Depression. The basal boundary is marked by the change of the Baskunchakian clay in the sandstones of the Middle Triassic. Two suites are recognised: the Eltonskaya and the Inderskaya (Fig. 9).

The Eltonskaya suite (T_{2el}). It begins with sandstones followed by clays and limestones. The total thickness varies from 100 to 400 m.

The lower part, terrigenous, contains the transitional complex with mainly Lower Triassic species and few Middle Triassic species (*Darwinula recondita* Schleifer, *D. lauta* Schleifer, *D. acmayica* Schleifer, *D. postinornata* Schleifer, *Suchonella flexuosa* Starojilova from the *Darwinula lauta* zone).

The upper part, clay and carbonates, is typical from the Middle Triassic (*Lutkevichinella involuta* Schneider, *L. bruttanae* Schneider, *L. minora* Starojilova, *Pulviella ovalis* Schneider, *Triassinella gubkini* Schleifer, *Clirocypris vasilievi* Schleifer, forming the *Lutkevichinella bruttanae* zone).

The Eltonskaya suite contains tetrapods as *Plagioscutum ochevi* Shishkin, Capitosauridae, referring to *Eryosuchus* which is well correlated with fauna of Central Europe (Shishkin & Ochev 1992).

The Inderskaya suite (T_{2in}). It presents clays and carbonates on a thickness of 100 to 250 m.

Both suites (Eltonskaya and Inderskaya) are characterised by a single Middle Triassic Darwinulocopida ostracods assemblage (*Darwinula obesa* Schleifer, *D. kiptschakensis* Schleifer, *D. lenta* Schleifer, *D. lauta* Schleifer, *D. recondita* Schleifer, *D. acmayica* Schleifer) but by different Cytherocopina ostracod assemblages. In the lower suite, there are *Glorianella inderica* Schleifer, *Renngartenella distincta* Starojilova, *Cytherissinella orispa* Schleifer from the *Glorianella inderica* zone. In the upper suite, the following species from the *Pulviella aralsorica* zone occur: *Pulviella aralsorica* Schleifer, *P. obola* Schleifer, *P. lubimovae* Schleifer, *P. directa* Starojilova, *P. marinae* Starojilova, *Speluncelia auerbachi* Schleifer, *S. spinosa* Schneider, *Inderella usunica* Schleifer, *Aralsorella uralica* Schleifer. Moreover, there are bivalves and gastropods *Unionites fassaensis* (Wissmann), *U. muensteri* (Wissmann), *Cryptonerita elliptica* Kittl, *Actaeonina mediocalcis* Hohenstein, vertebrates *Mastodonsaurus torvus* Konzhukova, *Plagioscutum caspiense* Shishkin, which allow the correlation with the lower Keuper of the Central Europe (Shishkin & Ochev 1992).

To the south-western part of the Depression, the Akmajskaya series presents mainly clays and the thickness grows up to 1200 m. To the west, on the borders, it changes in variegated terrigenous deposits of the Morovovskaya suite (275 m) with charophytes, ostracods and in some layers Cytherocopina of Inderskaya suite. To the east, the Akmajskaya suite is completely replaced by the variegated sand-clay Tashijskaya suite (T_2ts; 230 m; Fig. 3) with characteristic non-marine ostracods and charophytes. Outside of the Depression to the north and to the east, the Middle Triassic is missing.

The Aralsorskaya p.p.

This series contains grey to variegated terrigenous and calcareous deposits from Middle and Upper Triassic (Figs 11, 12). The Lower Jurassic Besobinskaya suite overlays it with important uncorformity (Shelechova *et al.* 1989). The Aralsorian is subdivided in six suites: Masteksajskaya, Almamyskaya, Chodinskaya (the three from the Middle Triassic), Koktinskaya, Shalkarskaya and Kusankudukaya (the three from the Upper Triassic).

The Masteksajskaya suite (T_{2mis}). It is composed of grey to black clays, aleurolites, rarely sandstones and limestones (210 m). It overlies the Akmajskian series (*Pulviella aralsoria* zone). Its red analogous deposits extend to the east through

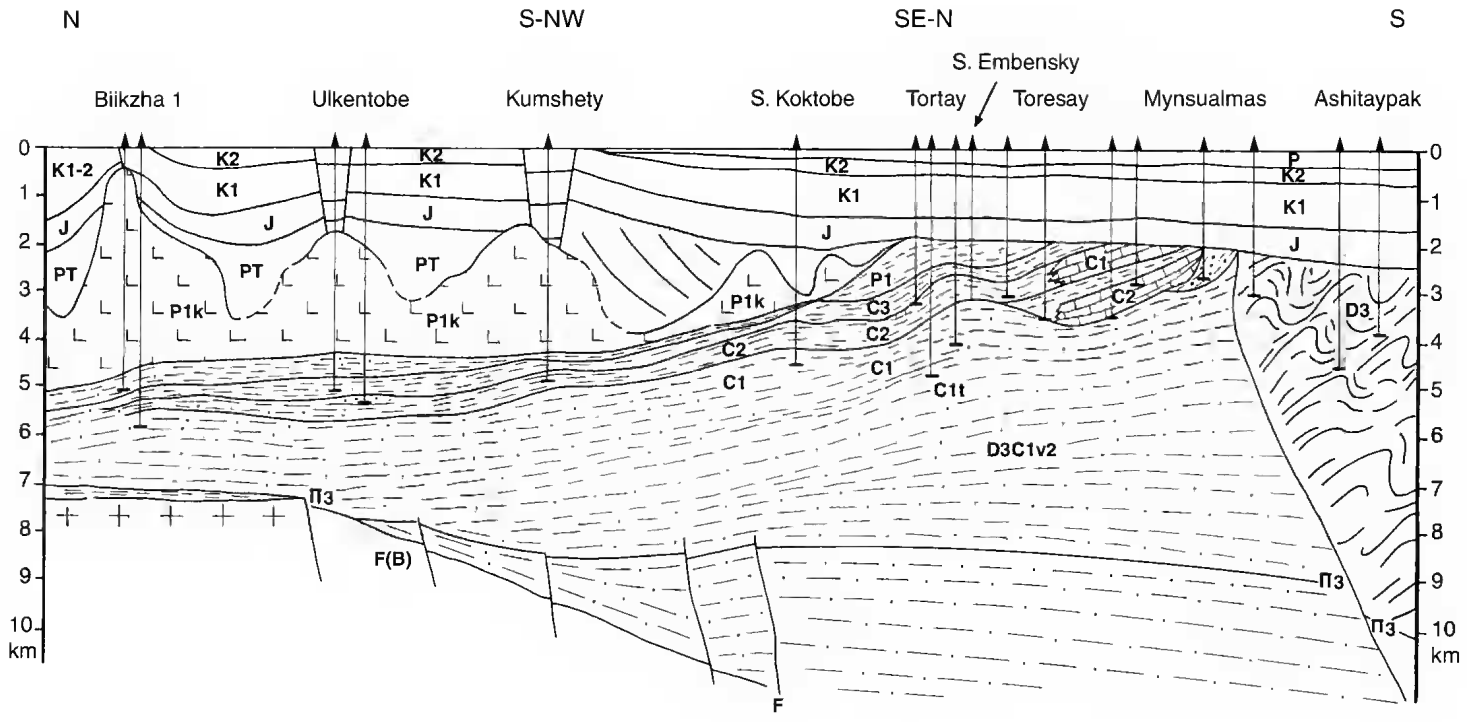

FIG. 5. — Geological-geophysical cross section GG 042 (location on Fig. 7). South-eastern/Eastern part of Precaspian Depression. Legend: see Fig. 2.

the boundaries of the Depression to the Donetz Through and the Pre-Ural. The suite is characterised by a rich ostracod assemblage where the species known in the underlying levels (*Darwinula lauta* Schleifer, *D. obesa* Schleifer, *D. infera* Schleifer, *D. kiptschakensis* Schleifer, *Pulviella aralsorica* Schleifer, *P. obola* Schleifer, *P. directa* Starojilova, *Speluncella spinosa* Schneider) are associated with species occurring for the first time [*Gemmanella schweyeri* Schneider, *G. magna* Kozur, *G. grammi* Kozur, *G. movschovichi* Kozur, *G. densistriata* Kozur, *G. meyevi* Kozur, *G. tuberculata* Schleifer, *Speluncella ascedens* Diebel, *Cytherissinella okrajantci* Schleifer, *C. sokolovae* Schneider, *Glorianella efforta* (Glebovskaya), *G. mirtovae* Schneider, *Renngartenella auerbachi* Schneider, *Casachstanella shungayica* Schleifer, *Telocythere fischeri* Kozur, *Lutkevichinella pseudopusilla* Kozur].

The Almamyskaya suite (T_{2al}). It is represented by grey and variegated terrigenous rocks (0 to 425 m) with Middle Triassic ostracods (*Gemmanella schweyeri* Schneider, *Pulviella ovalis* Schneider, *Speluncella spinosa* Schneider, *S. elegans* (Beutler & Grund), *Glorianella mirtovae* Schneider, *G. efforta* (Glebovskaya), *Renngartenella avdusini* Schneider, *Cytherissinella okrajantci* Schneider, *C.* cf. *elongata* Schneider, *Casachstanella shungayica* Schleifer, *Darwinula* sp.) and miospores.

The Chodinskaya suite (T_{2ch}). It is divided in two parts (Shelechova *et al.* 1988). The lower part is massive (Khodinskaya *s.s.*) and the upper part, which lies with unconformity, is the Khodinskaya suite. In the west, the Barmantsakskaya suite (Movshovich 1994) is equivalent to the Khodinskaya suite *s.s.* These suites are composed of grey and variegated clay, with interbeds of aleurolites, sandstones with siderite concretions and vegetal crumbs. In the north-east of the Depression, there are some coal interlayers. The thickness varies from 0 to 304 m. In the Barmantsakian suite, there are Middle Triassic ostracods (*Cytherissinella schleiferae* Starojilova, *Darwinula acmayica* Schleifer, *Suchonella* ex gr. *flexuosa* Starojilova, *Speluncella* ex gr. *spinosa* Schneider, *S.* ex gr. *alata levis* Kozur), as well as foraminiferas and charophytes. It can be note

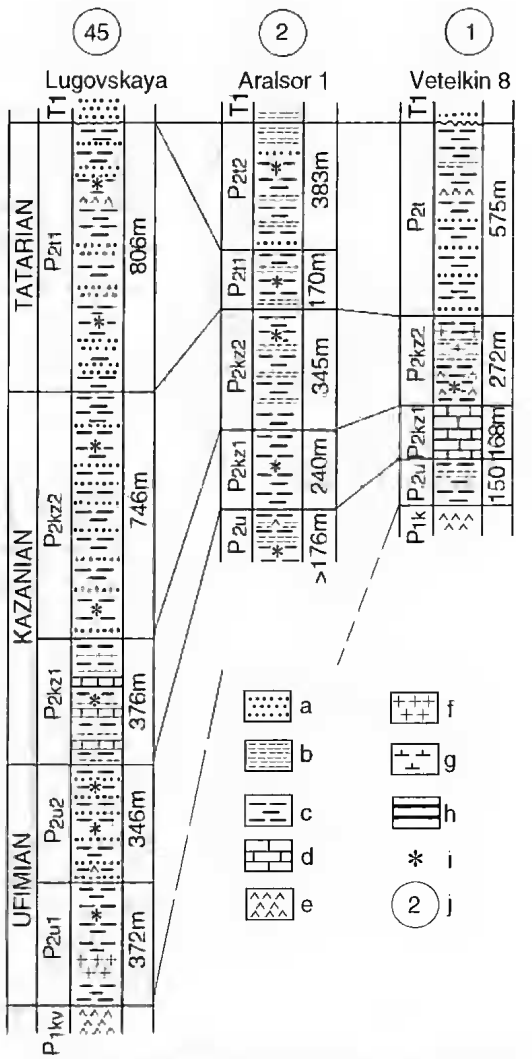

FIG. 6. — The Upper Permian of the Precaspian Depression illustrated by some representative boreholes (Lugovskaya 1, 45 on Fig. 7; Aralsor 1, 2 on Fig. 7; Vetelkin 8, 1 on Fig. 7). Legende: **a**, sand, sandstone; **b**, siltstone; **c**, shale; **d**, limestone; **e**, anhydrite; **f**, salt; **g**, carbonated shale; **h**, coal; **i**, red rocks; **j**, number of boreholes on palaeogeographic maps (Figs 7, 10, 12).

that *Speluncella alata levis* is related to the German basin at the top of upper ceratitic beds (Ladinian) (Kozur 1973).

The only section of the Aralsorian Middle Triassic series is present in the Zabutunian trough in the south of the Depression where 1200 m of sand-clay deposits with some interbeds of limestones [with ostracods as well as pelecypods *Triganodus*

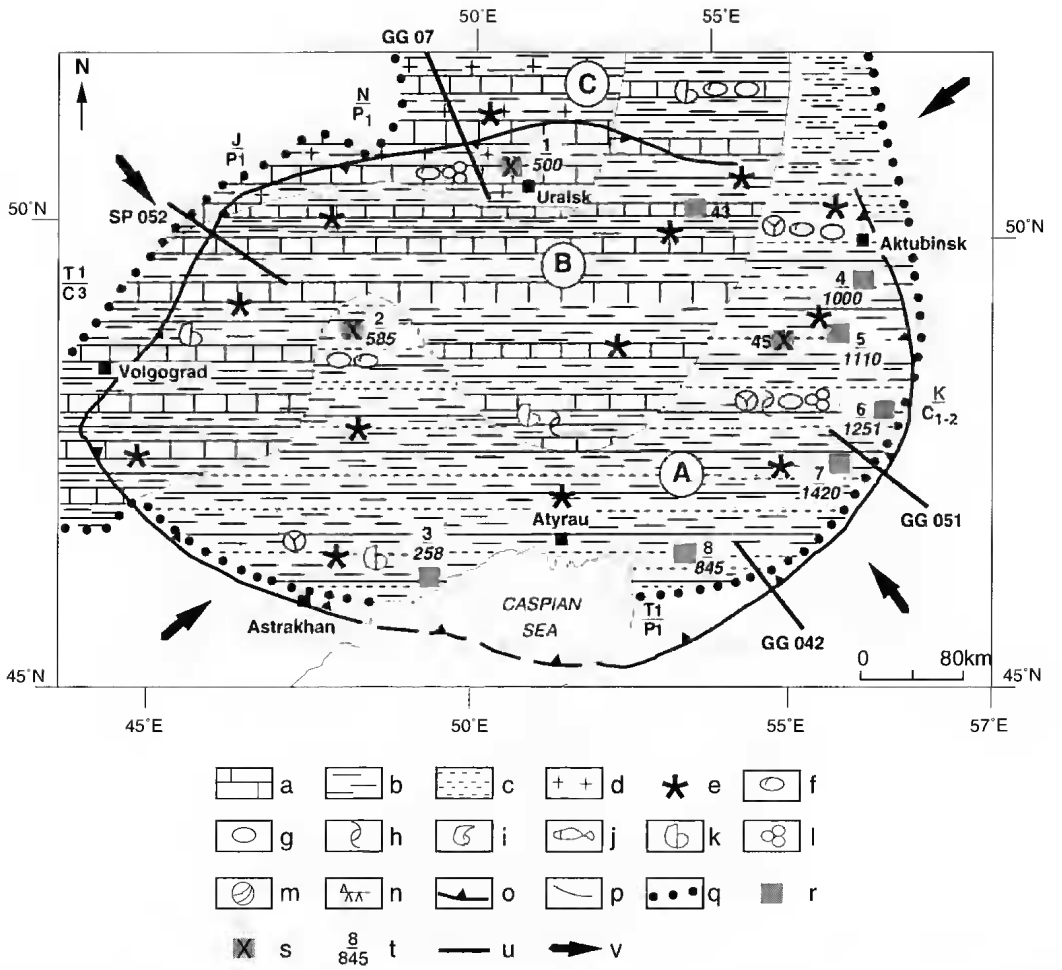

FIG. 7. — Kazanian lithological and palaeogeographical scheme of the Precaspian Depression. **A**, alluvial plain episodically flooded by the sea; **B**, **C**, area of marine (during lower Kazanian-kz1) and lacustrine (during upper Kazanian-kz2) carbonate-clastic (**B**) and salty carbonate (**C**) deposits. Legend for all the palaeogeographic maps: **a**, carbonates; **b**, shales; **c**, sandstones; **d**, salt; **e**, redding; **f**, marine ostracods; **g**, non-marine ostracods; **h**, pelecypods; **i**, cephalopods; **j**, fishes; **k**, brachiopods; **l**, foraminiferas; **m**, charophytes; **n**, vertebrates; **o**, Precaspian Basin boundaries; **p**, limits of lithological-palaeogeographical domains; **q**, limits of recent deposit abundance; **r**, boreholes; **s**, boreholes figured on figs 6, 8, 9, 11; **t**, number of boreholes (in the upper part number of the borehole; in the lower part, in italic, thickness); **u**, cross section of Figs 2-5; **v**, direction of detritical supplies. List of boreholes: **1**, Vetekin; **2**, Aralsor; **3**, Zhambay ; **4**, Sambay ; **5**, Karabulak ; **6**, Kokzhide ; **7**, Mujunkum ; **8**, Kulsary ; **43**, Linevka ; **45**, Lugov.

(?) *praelongus* Kiparisova, *T. sandbergeri* Alberti, *Schafhaeutlia silesiaca* Assmann, *Myophoriopsis gregaroides* (Philippi)] are drilled.

UPPER TRIASSIC (T_3) = ARALSORSKAYA SERIES *p.p. The Koktinskaya, Shalkarskaya and Kusankuduk-skaya suites*

The Upper Triassic part of the Aralsorskaya series lies with unconformity on Triassic or Permian.

The Koktinskaya suite (T_{3kk}). It is composed of sand-clay deposits (0-124 m) in the Aralsor, Kusankuduk and Prorvin troughs (respecrively central, eastern and south-eastern parts of the Depression; Table 1, Fig. 11). Shelechova (1988) described two palyno-complex *Chasmatosporites-Podosporites* and *Camarozonosporites-Gibeospo-rites*. The first one is described in the transitional interval of Middle-Upper Triassic and the second is characteristic of the middle and upper Keuper of the German Basin, the Carnian-Rhaetian

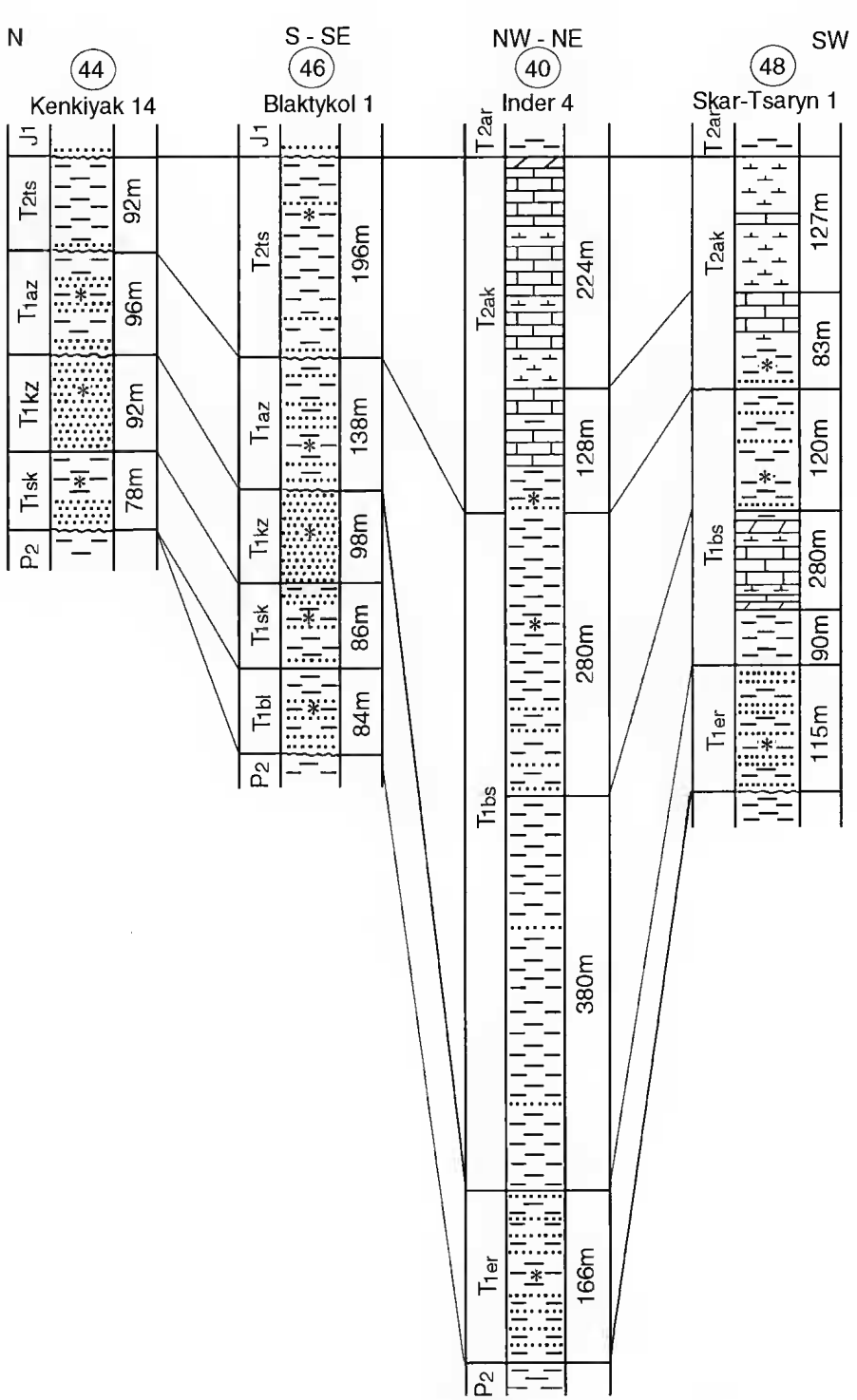

FIG. 8. — The Lower and Middle Triassic of the Precaspian Depression illustrated by some representative boreholes (Kenkiyak 14, 44 on Fig. 12; Blaktykol 1, 46 on Fig. 12; Inder 4, 40 on Fig. 12; Skar-Tsaryn 1, 48 on Fig. 12). Legend: see Fig. 6.

deposits of the Eastern Alps, Caucasus and Donbas (Shelechova *et al.* 1988).

The Shalkarskaya suite (T_{3sh}). It has also a sandy clay composition (Table 1, Fig. 11). Sandstones predominate in the lower part and clays in the upper part. The thickness varies from 0 (area between the Ural and Volga rivers, western and northern bordetlands of the Depression) to 84-228 m to the east. Different fossils are recognised: leaf-prints of *Clathropteris meniscoides* Brongniart (Carnian-Liassic) and palyno-complex *Neoraistrickia taylorii-Gibeosporites* (Carnian), Late Triassic conchostracans *Lioestheria kidoi* (Kobayshi), *L. shimamurai* (Kobayshi), *Pseudestheria (Sphaeropsis) tanii* (Kobayshi), *P. turkestanica* Novojilov & Kapelka, *P. gissarica* Novojilov & Kapelka, *Sphaerestheria koreana* (Ozawa & Watanabe), *Glyptoasmussia madygenica* Novojilov & Kapelka, *Laxomicroglypta kobayashi* Novojilov & Kapelka, *Limnadia gontsharovi* Kapelka, *Liograpta tomiensis* Novojilov.

The Kusankudukskaya suite (T_{3ks}). It is composed of sandstones, aleurolites, clays, mainly grey with some layers reaching 12-16 m (Table 1, Fig. 11). The total thickness is 0-300 m. The Rhaetian age of the suite is clearly established on miospores (Kukhtinov 1984): presence at the bottom of *Zebrasporites laevigatus* Schelechova, *Z. interscriptus* (Thiergart) Klaus, which are usually absent in Norian. The Norian-Rhaetian palyno-complex *Kyrtomisporites-Zebrasporites* is described by Schelechova *et al.* (1988). These authors showed that the Kusankudukskaya suite is absent in the ultra-deep Aralsor well (Fig. 4), in the central part of the Depression. So, it appears that the Kusankudukskaya suite and the Upper Triassic are absent from the most part of the western half of the Depression. Between the Ural and Emba rivers lower courses (Kukhtinov 1984), the Middle Triassic part of the Aralsorskaya series is missing and the Akmajskaya series (or Older Triassic) are overlay by Upper Triassic (about 220 m). Here, the Permo-Triassic series is more tectonically deformed than in other areas of the Depression. To the south (Prorva area) the analogues of the Akmajskaya have important thickness (to 407 m), more regular structure and display marls within sandy clays. Outside of the Depression, to the north, to the west and to the east, the Akmajskaya series is not subdivided as well as the underlying Akmajskaya series. The overlying Jurassic begins here only in the middle Bajocian.

PALAEOGEOGRAPHY OF THE PRECASPIAN DEPRESSION DURING LATE PERMIAN AND TRIASSIC

We are looking here to the Precaspian Depression and its adjacent areas. This territory is located at the south-eastern part of the Russian platform bordered by the Uralian and Donets-Ustjurt Hercynides. The palaeogeography is controlled by tectonic and climatic changes (from high arid during the Kungurian, to arid during the Late Permian and Early Triassic and humid during Middle-Late Triassic). The growing of salt domes during the Ufimian has significant influence on the deposional conditions.

Taking in account all the sections of the Upper Permian in the south and east of the basin, there is no significant lithological changes at the series boundaries.

The base of the Ufimian is represented by grey sediments. The red coloration increases little by little when we going up in the series. The presence of sulphate inclusions and of halogenous rocks (in some places) can be attributed to the development of the Ufimian basin and residual salt lakes; the geochemistry of the Kungurian and Ufimian (Solikamian) are very similar (Kukhtinov 1984). The main change occurs during Sheshmian. The progressive disappearance of the Kungurian salt-bearing sea takes place. The presence of grey sediments, vegetal debris and autigenic pyrite prove the restoration of normal depositional environments.

The Urals is the basic source of debris. The debris size and sand fraction content of the rocks increase to the east (Dmitrievskij 1966). The mineral composition of the Upper Permian detrital fractions is characterised by feldspathic graywake association and is represented by quartz (20-35%), feldspar (15-32%), fragments of effusive and carbonates rocks (45-48%) and rarely of metamorphic rocks (2-5%). In the central part of the basin, the quartz content increases.

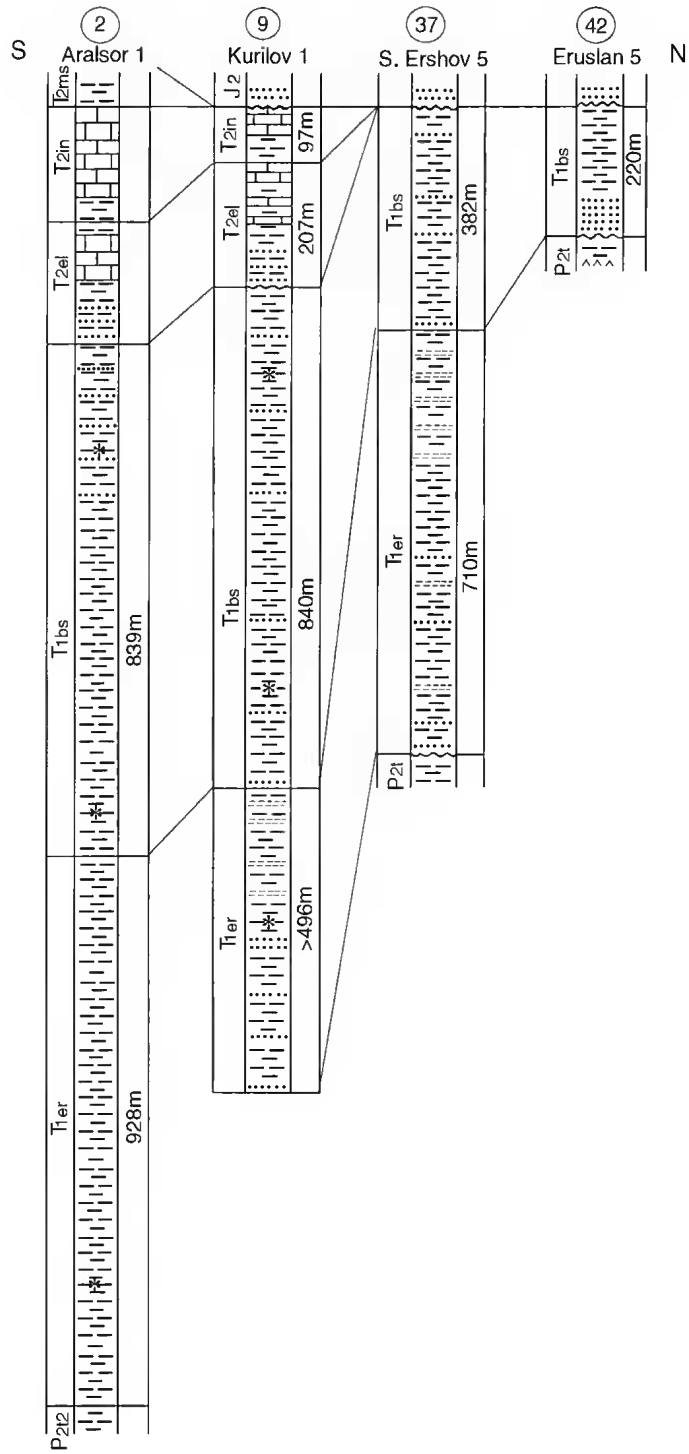

FIG. 9. — The Lower Triassic of the Precaspian Depression illustrated by some representative boreholes (Aralsor 1, 2 on Fig. 10; Kurilov 1, 9 on Fig. 10; South Ershov 5, 37 on Fig. 10; Erulsan 5, 42 on Fig. 10). Legend: see Fig. 6.

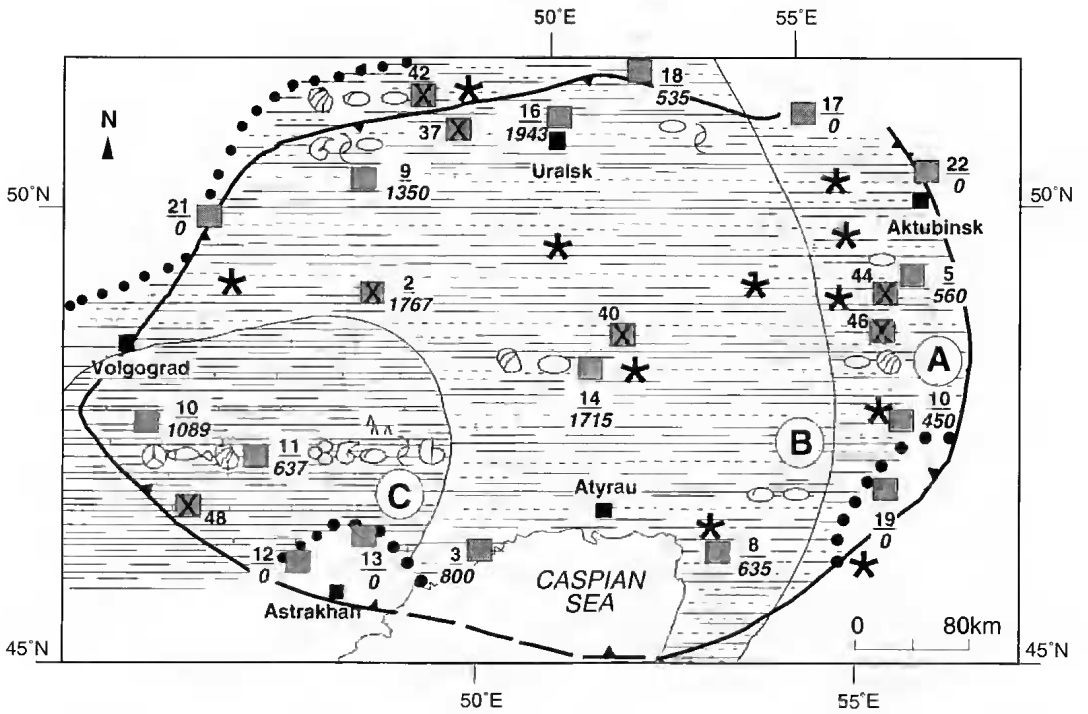

FIG. 10. — Lower Triassic lithological and palaeogeographical scheme of the Precaspian Depression. **A**, area of alluvial and proluvial deposits; **B**, alluvial plain, flooded episodically by the sea; **C**, epicontinental marine deposits. Legend: see Fig. 7. List of boreholes: **2**, Aralsor; **3**, Zhambay; **5**, Karabulak; **8**, Kulsary; **9**, Kurilov; **10**, Sadovaya; **11**, Bugrin; **12**, Stepnov; **13**, Zavolzh; **14**, Ushtobe; **16**, Chinarev; **17**, Mertvye Soli; **18**, Akzhar; **19**, Tuskum; **21**, Nikolaev; **22**, Podgornen; **37**, Ershov; **40**, Inder; **42**, Eruslan; **44**, Kenkiyak; **46**, Biaktykol; **48**, Shar-Tsaryn.

The second half of the Ufimian is defined by the accumulation of red sediments. The red coloration is conditioned by increase of aridity entails by wide development of red eluvium sediments enriched in ferrigenous pigment. This is the result of Fe deposition in clay minerals of montmorillonite and illite groups. The hydration degree of ferric oxides and the intensity of ochre increasing in eluvium are defined by temperature. It is not accidentally if the red coloration is developed in the arid steppes and desert areas of Kazakhstan and develop a brown coloration to the north. The coloration of rocks is defined by the Fe^{3+}/Fe^{2+} ratio (Janov 1956): with a value up to 3 it is red-brown to brown-red, between 1.6 and 3 it is violet to red-brick, lower than 1.6 it is green-grey to grey, 0 is black.

Probably in the basin sedimentation, predominance of oxidation conditions contributes to the preservation or subsequent increase of red coloration in the sediments. The oxidation conditions are confirmed by the low content of organic remains. The non marine bivalves and ostracods (Darwinulacea, which are representative of 2-3 m water deep, no more than 10 m) give evidence of the basin shallowness. On shore areas, in estuaries, the colonial algae (cyanophyceae) wide development in Aktubinsk Pre-Ural and probably in Precaspian Depression proves this assessment. In the miospore complex, the allochtonous elements come from conifers grown on the high lands.

During the Ufimian, the uplift of destruction areas and the development of salt domes begin in the trough. At the same time, in the depressions between the salt domes, syn-sedimentary lakes appear quite often, due to the washing of salt by underground waters. Such sedimentation takes place now in Inder Lake. The sedimentation in

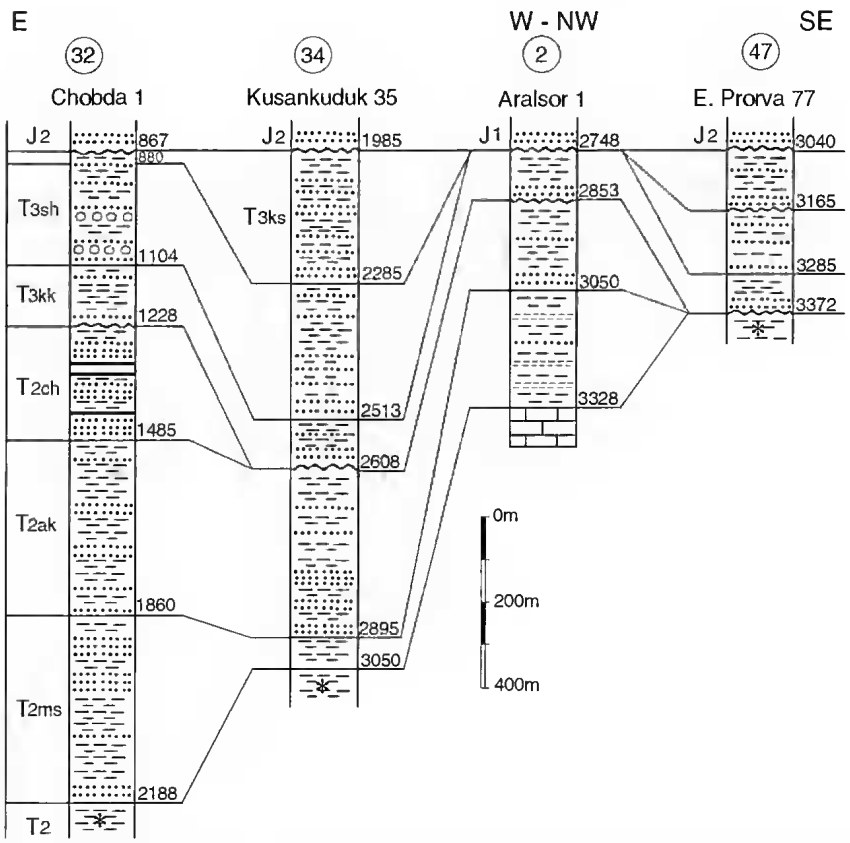

FIG. 11. — The Middle and Upper Triassic (Aralsorskaya suite) of the Precaspian Depression illustrated by some representative boreholes (Chobda 1, 32 on Fig. 12; Kusankuduk 35, 34 on Fig. 12; Aralsor 1, 2 on Fig. 12; East Prorva 77, 47 on Fig. 12). Legend: see Fig. 6.

the basin is controlled by difference between heightening zones (domes) and trough zones (between domes).

The Kazanian (Fig. 7) begins with the boreal sea transgression which follows the Urals to reach the northern Precaspian territory. Thin mainly carbonated rocks with shallow marine fauna (foraminifera, ostracods, bivalves, bryozoas, ...) are developed in the western, central and lesser in the eastern parts of the Depression. In the south (Zhambaj area) the sediments are represented by interbedding red and grey terrigenous sediments with some marine remains. The analogous rocks with marine ostracods were detected between Volga and Ural rivers (Aralsor well). The terrigenous material comes from the south, from Karpinski uplift and its eastern extension, and hinders the carbonate development. From time to time, the sea stretches far to the east, to Kenkijak and Makat (South Emba). Between red rocks, the interbeds of grey sediments contain foraminifera, crinoids and radiolarians (Kukhtinov 1984).

In the eastern part of the Depression, as far as its present boundary, an alluvial plain spreads out and, from time to time, is flooded by the sea. A thick sequence of aleurolite and argilite which contains only one bed of limestone, corresponds here to the marine limestone deposits. Fine detritic material is accumulated in the lakes without flow.

During the late Kazanian, the regression is caused by the Uralian orogenic movements. The late Kazanian succession is composed of terrigenous

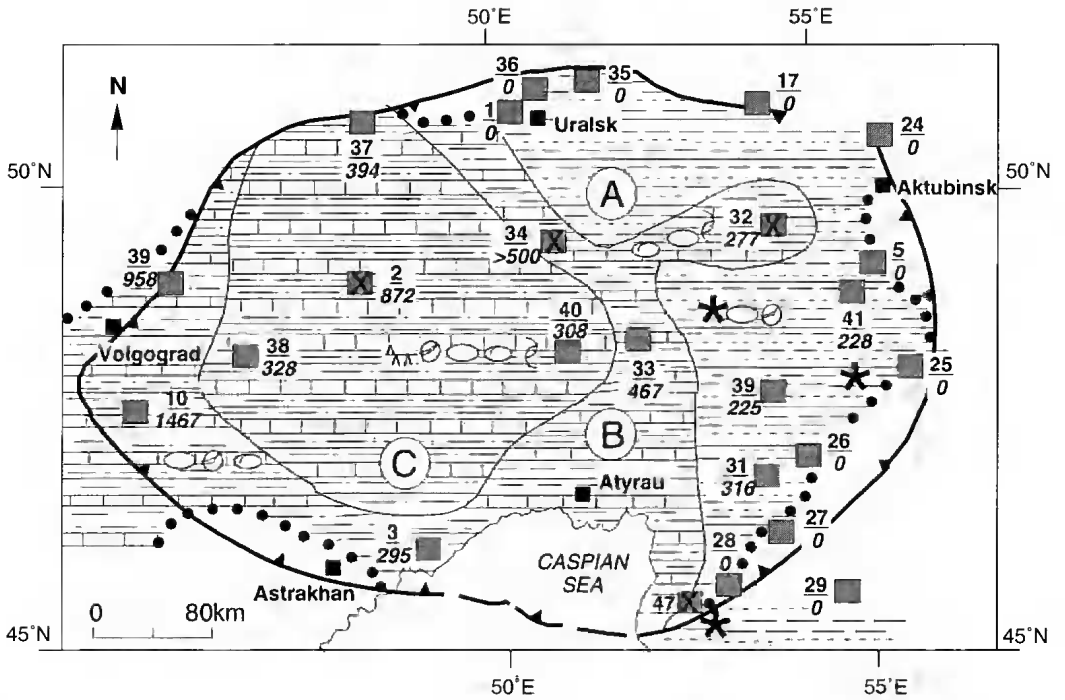

FIG. 12. — Upper Triassic lithological and palaeogeographical scheme of the Precaspian Depression. **A**, alluvial plain, flooded episodically by the sea; **B**, **C**, carbonate-clastic (**B**) and clastic-carbonate (**C**) deposits of shallow epicontinental sea. Legend: see Fig. 7. List of boreholes: **1**, Vetekin; **2**, Aralsor; **3**, Zhambay; **5**, Karabulak; **10**, Sadovaya; **17**, Mertvye Soli; **24**, Jusa; **25**, Zhanazhol; **26**, Chikembay; **27**, Mashly; **28**, Suishbek; **29**, Chumyshty; **31**, Zhusalysay; **32**, Chobda; **33**, Matenkozka; **34**, Kusankuduk; **35**, Pavlov; **36**, Teplov; **37**, Ershov; **38**, Shungay; **39**, Novonikol; **40**, Inder; **41**, Shubarkuduk; **47**, East Prorva.

sediments with coarse detritics including gritstones and conglomerates. These last ones are especially characteristic from the areas surrounding the domes.

In the residual water reservoirs of northern and western parts of the Depression, terrigenous sulphates and halogenous sediments are accumulated. In other areas, the sedimentation is terrigenous with alluvial, lacustrine and deltaic accumulations.

The continental basins contain a rich fauna of crustaceans and bivalves and numerous algae which characterise shallow environment. The salinity is no negligible judging to the Sr/Ba ratio equal to 2.3.

The total thickness of the Kazanian (about 1200 m) on the eastern part of the Depression shows that a large trough is present, compensated by detritic material from the Urals, Mugodzhar and South-Emba uplifts.

The Tatarian is characterised by continental environments. The alluvial North Caspian plain sinks slowly and is filled by sediments from lakes, rivers and temporal water streams. The Sr/Ba ratio falls from 2.3 to 1.3-1.1, this is typical an indicator of brackish water. Major inhabitants are non marine pelecypods, ostracods, algae (charophytes, red, brown, bushy cyanophyceae). The shallow basins are often dried (presence of mud cracks). The frequent cross-beddings are characteristic of the active hydrodynamic regime. The dome are eroded. Remains of Kungurian anhydrite are present in the early Tatarian series. In some places, especially in the south of Aktubinsk Pre-Ural area, the lake deposits are common – chemogenic limestones, clay with abundant organic matter. There are numerous charophytes and small fauna of bivalves.

A proluvial plain spreads out along the Urals area destruction. Detritical fan of temporal flows

reaches the Shubarkuduk area, especially during the late Tatarian. Cross-bedded sandstones of channel and delta types are developed in Kenkiiak and Mortuk areas. The intraformational washing out of the Tatarian is an indication of sedimentation above the basis of erosion (near dome area). The fine grained sand-aleurolite and pelitic material are accumulated in the lakes of the central areas.
In the surrounding emerged lands, there is an almost constant uplift which induces an intensification of erosion and formation of frequent interbeds of detritic material. It obviously takes place during Sevetodvinian when coarse detritical deposits begin to be widely distributed.

At the end of the Permian, the eastern and southern areas of the Depression are involved in the uplift which entails erosion of accumulated sediments and induces the unconformity of the Triassic on the Permian.

At the beginning of the Triassic (Fig. 10), the sedimentation atea is considerably smaller than the Permian one. In fact the structute of the sedimentation basin changed: in the early stages, the major sedimentary layers were located in the eastern part, later they are concenttated in the central part of the Deptession. The eastern, southern, south-western and ptobably northern peripheral patts of the Precaspian Depression were considetably uplifted and reptesent a baring area. The Tatarian and, sometimes in the south the Kazanian rocks were washed out. At the same time, the central part of the basin was not inverted. This is why the unconformity does occur between Permian and Triassic on the borders.

Slowly, the expansion of the sedimentation basin takes place. The presence of conglomerates and cross-bedded sandstones in the eastern and south-eastern parts of the Depression is due to the development of alluvial and proluvial deposits, step by step transformed into submarine-deltaic and lake deposits (Dmitrijevskij & Proshljakov 1970). In the eastern part of the Depression, channel flows, in the a sublatitudinal direction, cut (Mortuk, Kenkijak, Kokshide) or walk around (Shengelshij) the domes which are uplifted (Pronieheva & Savinova 1980). When the domes are cutting, a wide development of coarse detritics rocks probably caused by the formation of a blind delta is observed. On the whole a piedmont-fan type of detrital material distribution is manifested in this area.
In the central regions, the deposits are represented mainly by fine-grained sands, more often by aleurolites and pelites due to the multiple redepositions and transfers during that time. Therefore, the rocks have high mineralogical (quartz and feldspar content teaches 80-90%) and textural maturity.
The Early Triassic deposits have a high content of epidote in heavy fraction coming from the erosion of metamorphic rocks of Ural and Mugodzhar, following by a rapid burying.
The water reservoirs are mainly fresh water (Sr/Ba = 0.7 – Demchuk *et al.* 1971) with charophytes, ostracods and other crustacean. The presence of mud-cracks, worm activity tracks, and other emphasise the shallowness. Depressions with lack of dtainage and salt lake types were well developed.

From the Olenekian, a clear change in climatic conditions takes place. The transgression coming ftom the south, i.e. from Caucasus and Tethys, induces an increasing of the humidity. The sea covers the south-westetn part of the Deptession; from time to time it widens its boundaries down to the southern petiphery and Biikjal, in the east (Fig. 10). At this time, carbonate and sandy clay sediments accumulated here. At first, the basin is connected with Tethys and it contains normal marine fauna – brachiopods, ammonoids, foraminiferas, conodonts, fishes, ostracods with genera of Cypridacea and Cytheracea (*Clinocypris*, *Spinocypris* and especially *Triassinella*). In the South, the ostracods *Bairdia*, *Bairdiacypris* and *Healdianella* are very common. In other times, the basin has poor connections with the ocean. The basin is a slightly salted one (Sr/Ba = 0.9). The fauna is represented by ostracods, bivalves, gastropods, worms, fishes and chatophytes. Along the coasts, the xerophytes of *Pleuromeia* and Lycopodiacea type are growing. The coast lands are flat-hilly plain, alluvial and proluvial sediments settle. Close to the destruc-

tion areas, coarser deposits occur on a piedmont plain. The detrical material comes from the erosion of Urals to the east and from the Voronesh anticline and the Donets fold system to the west and to the south (Movshovich 1977; Janochkina & Startsev 1977). The upward salt domes of Upper Permian are additional source rocks. In Baskunchak and Inder Lakes area, there are relatively coarse deposits formed by drag flows (Movshovich & Tsebenko 1974). The syn-sedimentary uplift of domes leads to the change of the erosional bases and to intraformational washing out in the sections. The tracks as pebble gravel lenses occur especially often in the upper part of the Bashkuchakian series.

Eolian formations are present in the Early Triassic deposits; in sandstones and clays, the quartz grains have characteristic blunt surface and striations.

Sandstones and aleurolites with bad granulometric sorting and heterogeneity of fragmentary grains are due to the different sources of erosion material. The presence of well-preserved Carboniferous rocks in the Lower and Middle Triassic sediments at Matenkozha (left bank of Ural River) suggests that not only the Permian but also the Carboniferous rocks from uplifted surrounding areas are eroded (Kukhtinov *et al.* 1982).

The existed water basins are quite shallow. In rocks, numerous cracks from drying are found, stream bedding and organic remains, adapted to environment with temporary drying-up – amphibians, ostracods, fishes, conchostraceans. Oxidising conditions prevailing here. Only in the middle Olenekian marine basin, with clay and limestone deposits, the environment changes to regenerating. More active processes of chemical erosion take place. Judging to the osttacod distribution, multicoloured and red sediments are formed not only in continental environments but also in the periphery of salty basin.

At the end of the Early Triassic, the sea regresses and continental regime dominates.

The Middle Triassic (Fig. 12) is characterised by a new incursion of the sea and its area of distribution is quite the same than previously. The great change between Lower and Middle Triassic deposits is probably due to ingression along river channels. The normal transgressive sequence – sandstones, clays, limestones – of the Akmajskaya series and variegated terrigenous deposits of the surrounding flatlands are developed. The remains of ostracods, molluscs, fishes and charophytes, not clearly marine, indicate the hindered connection with the ocean. The Stavropol uplift of Northern Caucasus, of Middle Caspian, of Karabogaz and Buzachink domains, the emerged eruptive massifs of Mangyshlak as well as organogenic buildings could be considered as palaeogeographic barriers.

During the second half of the Middle Triassic, carbonate deposits are occasional. Almost everywhere, grey and rarely variegated sands, aleurolites and clays are deposited. The area of distribution is considerably extended outside of the Depression, i.e. into the southern Pre-Ural and Pre-Uralian trough. In the north-eastern part of the Depression, the marine environments are episodically replaced by transitional zones (coastal plains with coal accumulations). Numerous ostracods, including the brachihaline *Gemmanella* genus, are associated with these deposits (Aralsorian series). Single marine euhaline *Bairdia* genus is found with them.

During the Late Triassic, approximately the same situation is preserved. Under a humid climate, there is great abundance of hygrophytes on insular and coastal lands, conifers with fern underbrush and pteridosperms on high lands. In the transitional areas, herbaceous swamps and overgrown lakes are widely developed. In the basin, the conditions are changed time to time into oxidising shallow water environments. The irregular interbedding of sands and clays shows the eustatic movements. The central areas of the Depression subside intensively with important filling. The increase of terrigenous material shows the uplift of emerged areas. The regression continues and the continental environments dominate.

At the end of the Triassic-beginning of the Jurassic, the Precaspian Depression, especially its western part and the adjacent areas, are uplifted and become erosion lands.

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